OPERATING SUMMARY

WATER TREATMENT PLANTS

1968

ONTARIO WATER RESOURCES COMMISSION

Division of Plant Operations

1968 ANNUAL OPERATING SUMMARY

ONTARIO WATER RESOURCES COMMISSION

WATER TREATMENT PLANTS

Prepared by the
Project Services Section,
Division of Plant Operations.

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CONTENTS

PREFACE

The first summary of water treatment plant operation was prepared in 1967. It was essentially a summary of available data.

In the 1968 summary, though little additional data were available, some attempts at correlating treatment parameters were made so that they could be presented in a more useful form.

The curves were fitted by the method of least squares. Those correlations presented are significant for an α of 0.05. There is therefore less than a 5% probability that no relation of this type exists. The relations developed apply only within the range of data available, and the best fit for data outside this range need not necessarily be of the same form.

While the data in this report are limited, it is hoped that with the co-operation of staff directly concerned with the operation of these projects, more information will be available in the future. Suggestions and criticisms of both data compiled and technical analyses are welcomed.

LIST OF TABLES

LIST OF GRAPHS

PLANTS INCLUDED IN REPORT

SOLIDS (ALGAE & TURBIDITY) REMOVAL	DESIGN CAP. (MGD)	STORAGE CAPACITY MG	TREATMENT UNITS	RAW WATER SOURCE
1. Bertie Twp. 6-0047-59	4.5	.125 (clear well)	Microstrainer	Lake Erie
2. Dunnville 6-0017-58	20.50	.200 (clear well)	Microstrainer	Lake Erie
3. Harrow 6-0004-57	1.25	.300 (el. tank)	Microstrainer	Lake Erie
4. Fenelon Falls 6-0057-60	0.360	.008 (clear well)	Sand filter (pres.)	Cameron Lake
5. Meaford 6-0029-59	3.744 US	.200 (clear well) .125 (el. tank)	"Anthrafilt" filter (gravity)	Nottawasaga Bay
6. Marmora 6-0025-58	0.216	.435 (standpipe)	D. E. /Act. carbon filter (vac.)	Crow River
7. Southampton 6-0124-63	1.000	.100 (el. tank)	D. E. filter (pres.)	Lake Huron
8. Dresden 6-0007-57	0.500	0.19 (hi lift well) 0.67 (el. tank)	"ACCELATOR" solids contact unit (coagulation & softening)	Sydenham River
9. Eganville 6-0093-61	0.150		Alum coag; Sand filter (gravity)	Bonnechere River
10. Lake Huron 5-0001-64	37.00	1.4 (clear well) 12.0 (reservoir)	Alum coag; Sand & anthracite filter (gravity)	Lake Huron
11. Beaverton 6-0083-61	0.666 US	.100 (standpipe)	Alum & Act. Carb (No floc. tank) Clarifier; Sand filter (pres.)	Lake Simcoe
12. Goderich 6-0069-60	1.50	.091 (reservoir) .200 (el. tank T.) .250 (el. Tank O. H.)	Alum coag; Clarifier, Sand filter (gravity)	Lake Huron
13. Warkworth 6-0148-65	0.100	.110 (reservoir)	Alum coag; Clarifier, Sand filter (gravity)	Mill Creek
14. Union 6-0012-57	7.60	1.73 (reservoir) .33 (el. tank)	Microstrainer, Alum coag; Clarifier, Sand filter (gravity)	Lake Erie
IRON REMOVAL				
15. Brooklin 6-0053-59	0.216 US	.075 (el. tank)	Chlorination; Sand filter (pres.)	Well
16. Fauquier Twp. 6-0078-61	0.072	.011 (clear well)	Aeration; Sand filter (pres.)	Well
17. Markham Twp. 6-0104-62	1.00	.125 (reservoir) .250 (el. tank)	Aeration; Anthracite filter (pres.)	Well
18. Mitchell 6-0042-59	0.720	.060 (clear well)	Aeration "Anthrafilt" filter (pres.)	Well
WATER SOFTENING (ALSO IRON REMOVAL)				
19. Schomberg 6-0061-60	0.144	.100 (standpipe)	Sodium cation exchangers	Well
20. Oak Ridges 6-0061-60	0.468	.100 (standpipe)	Zeolite units	Well
SULPHIDE REMOVAL				
21. Parkhill 6-0045-59	0.504	0	Chlorination & Aeration	Well

PLANT FLOWS

Graph No. 1 displays maximum daily flows as percentages of the nominal capacities of the treatment plants, ranked in order of decreasing loadings. The graph also shows the percentage of time when daily flows exceeded 80% of design capacity. This figure (80% of design) was chosen arbitrarily to describe somewhat more closely the distribution of flows. Perhaps there exists a more meaningful figure, which could be used in future reports to determine when plant expansion is necessary.

Table I summarizes flow data, including maximum rates of flow where available. There is no relation between maximum rate (as a percentage of maximum day) and storage capacity, although it would seem logical for one to exist. Given sufficient storage, it should be possible to deplete a portion of the stored water during periods of high demand and replenish it during the night, thereby reducing the peak rates.

GRAPH No. 1

PLANT FLOWS

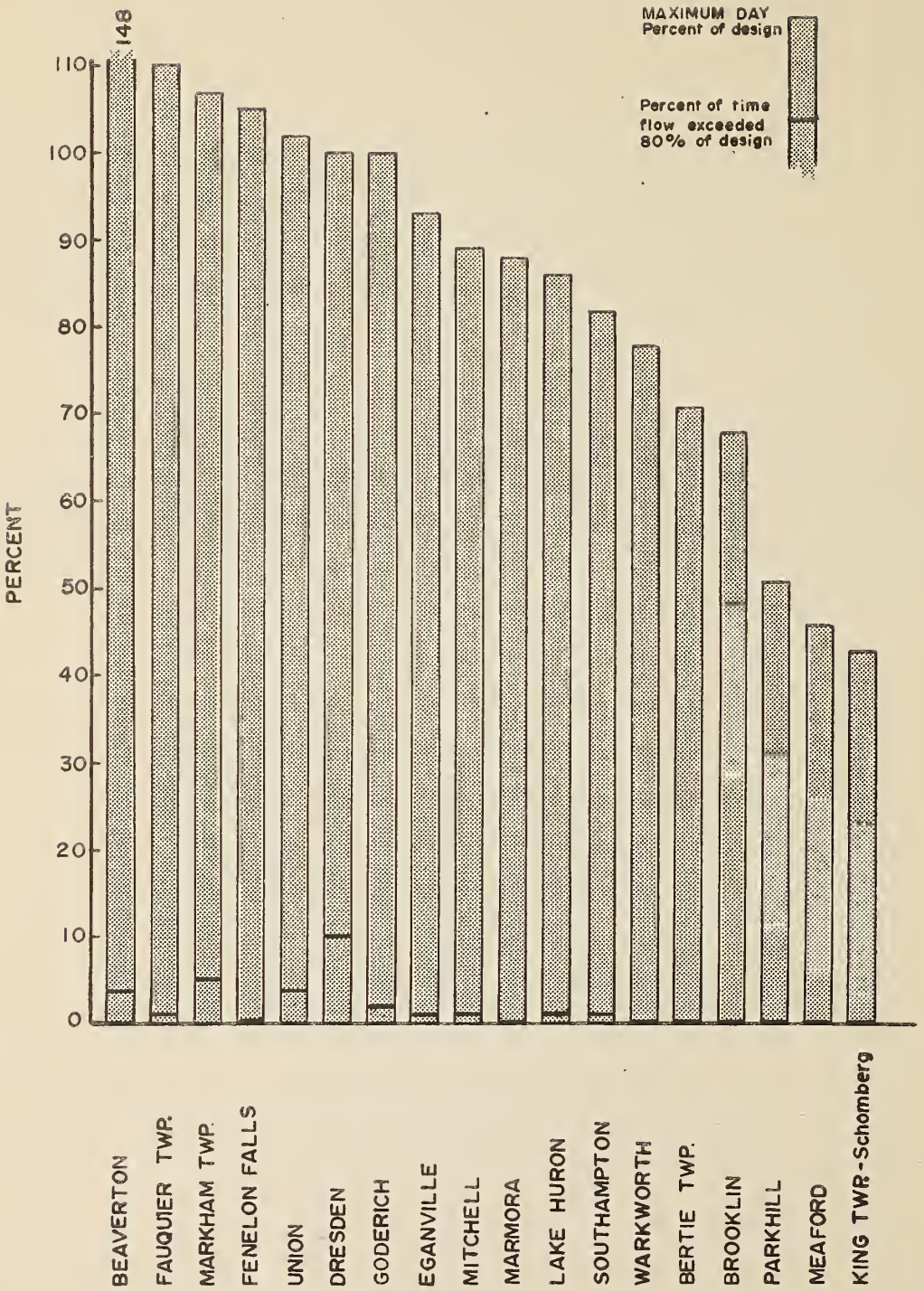


TABLE I PLANT FLOWS 1968

PROJECT	Nominal Capacity MGD	Annual Total MG	Mean Daily Flow		Maximum Daily Flow		Maximum Rate MGD
			MG	% of Design	MG	% of Design	
Beaverton	0.68	128.5	0.351	51	1.015	148	-
Bertie Twp.	4.50	512.3	1.40	31	3.190	71	5.6
Brooklin	0.216	13.62	0.037	17	0.147	68	-
Dresden	0.500	114.1	0.31	62	0.500	100	-
Dunnville	20.5	3422.	9.35	46	13.68	67	14.3
Eganville	0.15	18.66	0.05	34	0.14	93	-
Fauquier Twp.	0.072	12.44	0.034	47	0.080	111	-
Fenelon Falls	0.36	48.78	0.13	36	0.38	105	-
Goderich	1.5	252.9	0.69	46	1.49	100	2.5
Harrow	1.25	-	-	Not Available	-	-	-
King Twp. - Oak Ridges	0.47	-	-	Not Available	-	-	-
- Schomberg	0.14	-	-	Not Available	-	-	-
Lake Huron	37.0	7706.0	21.1	57	31.8	86	42.0
Markham Twp.	1.0	128.2	0.435	44	1.07	107	1.0
Marmora	0.216	34.04	0.09	43	0.19	88	0.21
Meaford	3.74	327.8	0.90	24	1.73	46	1.73
Mitchell	0.72	85.53	0.234	32	0.644	89	0.72
Parkhill	0.50	37.12	0.101	20	0.256	51	-
Southampton	1.00	100.9	0.28	28	0.82	82	-
Union	7.6	1466.0	4.06	53	7.80	102	9.8
Warkworth	0.10	10.09	0.027	27	0.078	78	-

PROCESS CHEMICALS

Chemicals used in the treatment process, other than chlorine, are summarized in Table II. The total quantity used, and the average dosages used are listed.

The amount of lime used at Dresden is the actual weight as supplied. The dosage, however, is based on a 70% calcium oxide content.

The quantities of alum used at Dresden, Eganville and Warkworth represent weights of chemical supplied. The other plants (Lake Huron, Goderich and Union) used liquid alum; the amounts shown are for pure Al_2O_3. The volume of liquid alum used in gallons can be obtained by multiplying the quantity of Al_2O_3 (in lb.) by 1.095. For comparison purposes the dosage is listed as milligrams of aluminum ion per millilitre of water. The multiplication factor to convert dosage to:

$Al(OH)_3$ is 2.88
$Al_2(SO4)_3$ is 6.34
Al_2O_3 is 1.89

Activated carbon was used at Marmora and Union only when the raw water was highly coloured. The dosages recorded are average values based on the flow when activated carbon was used.

The amounts used and dosages of diatomaceous earth include precoats.

Saturated brine was used at King Twp., Oak Ridges and Schomberg to regenerate the ion exchange units.

There appears to be no relation between chemicals used and water quality.

TABLE II

PROCESS CHEMICALS

Project	Total Flow MG	Lime		Alum		Activated Carbon		Diatomaceous Earth		Saturated Brine	
		10^3 Pound Lime	Dosage mg/l CaO	10^3 Pound Alum	Dosage mg/l Al	Pound	Dosage mg/l	Pound	Pound per MG	10^3 gal.	gal. per MG
Marmora	34.04	0	-	0	-	16	5*	7100	210	0	-
Southampton	100.9	0	-	0	-	0	-	86300	860	0	-
Beaverton	128.5	0	Not Available								
Dresden	114.1	145	89	15.0	2.4	0	-	0	-	0	-
Eganville	18.66	0	-	4.1	3.5	0	-	0	-	0	-
Lake Huron	7706.	0	-	295.0	2.0	0	-	0	-	0	-
Goderich	252.9	0	-	32.3	6.8	0	-	0	-	0	-
Warkworth	10.09	0	-	1.19	1.9	0	-	0	-	0	-
Union	1466.	0	-	35.8	1.3	2100	14*	0	-	0	-
Schomberg	9.08	0	-	0	-	0	-	0	-	14.0	1540
Oak Ridges		0	-	0	-	0	-	0	-	23.9	-

* Denotes dosages when used

Note: Alum doses based on total alum used and total plant flow.

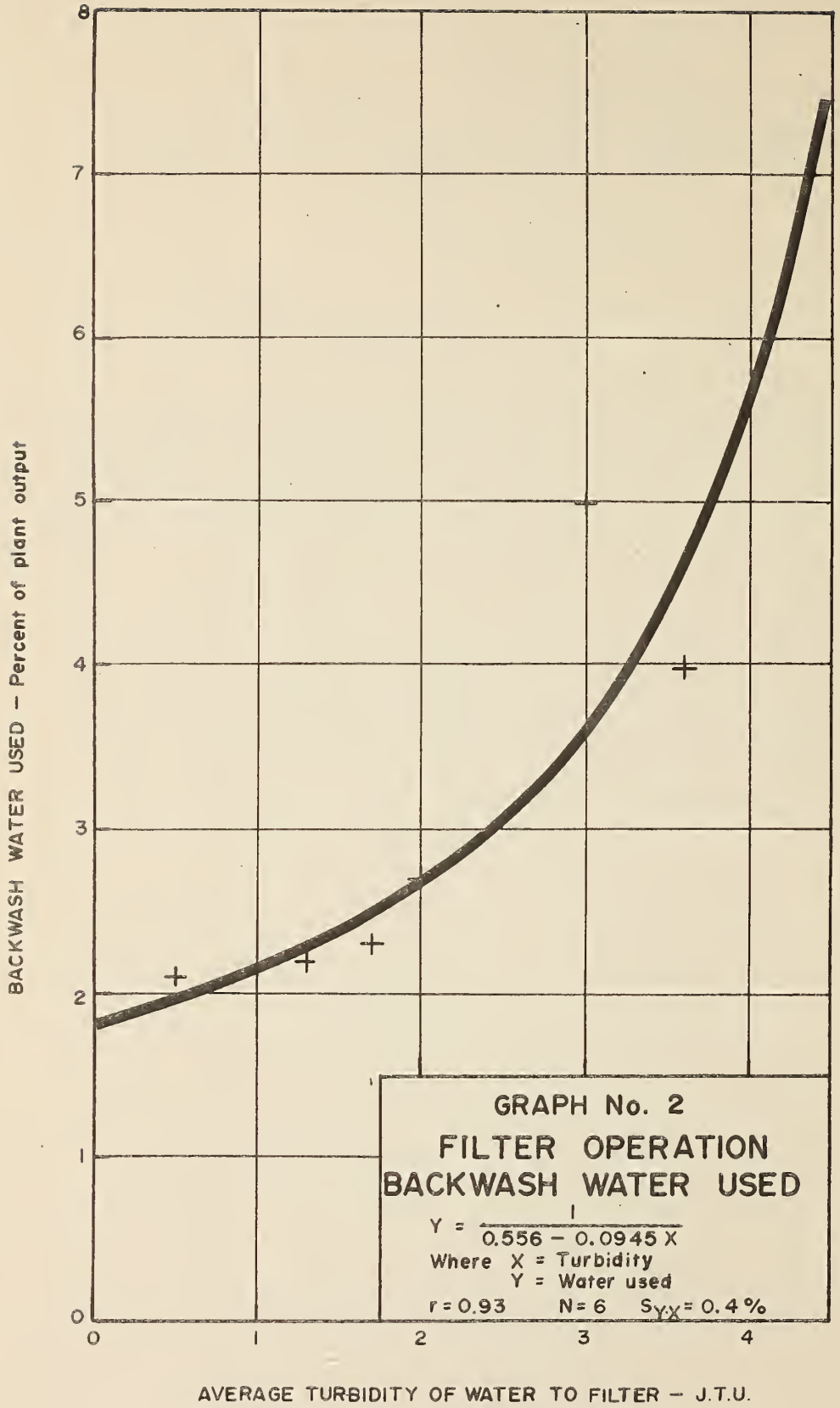
FILTER OPERATION

The data available on filters are presented in Table III. In most instances, information on lengths of filter runs, filter rates, etc., is not recorded. Graph No. 2 illustrates a relation between average turbidity of water to the filter and the amount of backwash water used. The filters considered in this correlation included both sand filters and diatomaceous earth filters.

TABLE III

FILTER OPERATION

Project	Total Plant Flow MG	Average Turbidity-JTU		Filter Backwash		
		Water to Filter	Filtered Water	Number of Backwashes	Water Used MG	Percent of Output
Beaverton	128.5	-	2.6	108	-	-
Brooklin	13.62	-	-	-	-	-
Eganville	18.66	2.5	2.5	103	Not Available	
Fauquier Twp.	12.44	-	-	126	-	-
Fenelon Falls	48.78	0.5	0.5	174	1.01	2.1
Goderich	252.9	3.6	0.9	512	10.05	4.0
Lake Huron	7706.	3.0	0.7	-	386.62	5.0
Markham Twp.	128.2	-	-	-	-	-
Marmora	34.04	3.2	1.5	97	-	-
Meaford	327.8	1.3	0.6	440	7.26	2.2
Southampton	100.9	2.0	0.2	270	2.70	2.7
Union	1466.	1.7	0.2	335	33.48	2.3
Warkworth	10.09	-	2.3	176	-	-


BACKWASH WATER USED – Percent of plant output
AVERAGE TURBIDITY OF WATER TO FILTER – J.T.U.
0
1
2
3
4
5
6
7
8
0
1
2
3
4
GRAPH No. 2
FILTER OPERATION
BACKWASH WATER USED
Y = 1 / (0.556 – 0.0945 X)
Where X = Turbidity
Y = Water used
r = 0.93 N = 6 S_{YX} = 0.4 %

CHLORINATION

Chlorination data are summarized in Table IV. Data from Brooklin (Whitby Twp.) are incomplete. The amount of diluted sodium hypochlorite solution used is recorded, but not its concentration. No data at all were available for the other plants noted "not available".

The dosages listed are averages based on total chlorine used and total water produced. At Parkhill, chlorine is used to oxidize the sulfides present in the raw water. Even with the high dosage used there, disinfection is not effected (see Table V, Bacteriological Quality).

TABLE IV

CHLORINATION

Project	Total Flow MG	Chlorine Used (Pound)			Dosage mg/l
		Prechlorination	Postchlorination	Total	
Beaverton	128.5	-	-	2700	2.1
Bertie Twp.	512.3	0	5600	5600	1.1
Brooklin	13.62	Not Available		-	-
Dresden	114.1	0	3000	3000	1.8
Dunnville	3422.	0	34600	34600	1.0
Eganville	18.66	860	0	860	4.6
Fauquier Twp.	12.44	-	-	160	1.3
Fenelon Falls	48.78	0	1030	1030	2.1
Goderich	252.9	2800	300	3100	1.2
Harrow		Not Available		-	-
King Twp. -Oak Ridges		Not Available		-	-
-Schomberg		Not Available		-	-
Lake Huron	7706.	85300	0	85300	1.1
Markham Twp.	128.2	Not Available		-	-
Marmora	34.04	0	770	770	2.3
Meaford	327.8	0	3100	3100	0.9
Mitchell	85.53	Not Available		-	-
Parkhill	37.12	0	4600	4600	12.3
Southampton	100.9	0	1000	1000	1.0
Union	1466.	38200	12700	50900	3.5
Warkworth	10.09	220	130	350	3.5

BACTERIOLOGICAL QUALITY

Table V is a summary of bacteriological sampling carried out during the year and the minimum number of samples required in accordance with the standards outlined in Drinking Water Objectives (an OWRC publication). The frequency of sampling of both raw and treated water leaving the plant is once a week for surface water sources and twice a month for ground water sources, producing a minimum number of samples of 52 per year for surface waters and 24 for ground water. These minimum sampling objectives were not met in a large number of cases.

The minimum number of samples and sampling frequency for distribution systems is given in a table in Drinking Water Objectives and is reproduced below.

Population Served	Minimum Number of Samples Per Month	Minimum Frequency of Sampling Intervals
Up to 1,000	2	2 per month
1,001 to 100,000	10 + 1 per 1,000 of population	1 per week
Over 100,000	100 + 1 per 10,000 of population	1 per day

Again, a large proportion of plants did not meet this requirement, though in some cases additional samples taken by Medical Officers of Health were not available.

TABLE V

BACTERIOLOGICAL QUALITY

PROJECT	RAW WATER					PLANT EFFLUENT			DISTRIBUTION SYSTEM		
	Minimum Samples Required Per Year	Samples with coliform Counts (in bacteria/100ml of)				Minimum Samples Required Per Year	Samples Taken	Samples With Coliforms >0/100ml	Minimum Samples Required Per Year	Samples Taken	Samples With Coliforms >0/100ml
		0	1-10	11-100	>100						
Beaverton	52	2	2	6	1	52	12	0	168	24	2
Bertie Twp.	52	4	6	14	1	52	28	0	288	89	5
Brooklin	24	5	0	0	0	24	4	0	24	8	0
Dresden	52	2	0	1	6	52	12	0	156	4	0
Dunnville	52	32	2	24	19	52	52	2	120(a)	222	5
Eganville	52	0	0	0	0	52	0	0	24	0	0
Fauquier Twp.	24	14	0	0	0	24	3	0	24	6	0
Fenelon Falls	52	2	6	13	3	52	25	0	120	72	0
Goderich	52	23	11	11	5	52	54	0	204	169	2
Harrow	52	34	5	7	1	52	49	0	144	126	0
King Twp. - Oak Ridges	24	1	0	0	0	24	4	0	24	7	0
- Schomberg	24	18	0	0	0	24	17	0	24	33	0
Lake Huron	52	183	8	0	2	52	120	0	1452	880	2
Markham Twp.	2 x 24	123	5	1	3	2 x 24	53	0	168	197	6
Marmora	52	0	4	4	2	52	10	0	24	20	0
Meaford	52	16	12	14	7	52	52	2	228	104	1
Mitchell	24	37	0	0	0	24	32	0	144	64	0
Parkhill	24	47	1	1	0	24	66	12	120	117	18
Southampton	52	37	0	3	1	52	2	0	156	136	0
Union	52	3	3	19	27	52	12	0	600	134	1
Warkworth	52	26	1	13	3	52	24	0	24	48	2

* Based on 100 gal. per day per capita
(a) Considered to have 1000 direct consumers

PHYSICAL AND CHEMICAL CHARACTERISTICS

PHYSICAL CHARACTERISTICS

Turbidity and colour of raw and treated water are summarized in Table VI. Only median (or for some plants, modal) values are listed for raw water; whereas median (or modal) values, maxima and the percentages of samples exceeding the limits of one J. T. U. turbidity and five apparent colour units are listed for treated water.

The minimum sampling frequency recommended in Drinking Water Objectives is one sample weekly.

Medians rather than arithmetic means are used where only a small number of samples are available since, in these cases, median values provide more meaningful averages. The median is less affected by extreme values, and hence should better describe the central tendencies of the distribution. Modal values -- the numbers occurring most frequently -- are used for plants where large numbers of determinations were performed. Maxima are given for treated water, their significance being that these are the only values which consumers will remember.

CHEMICAL CHARACTERISTICS

The minimum sampling frequency is only twice per year, yet even this was not fulfilled by several plants.

Table VII summarizes the chemical characteristics most commonly determined by the OWRC laboratory.

TABLE VI

PHYSICAL CHARACTERISTICS

1968

PROJECT	TURBIDITY IN JTU						COLOUR IN APPARENT COLOUR UNITS					
	RAW		TREATED				RAW		TREATED			
	Number of Samples	Median	Number of Samples	Median	Max. Day	% of Samples > 1.0 (JTU)	Number of Samples	Median	Number of Samples	Median	Max. Day	% of Samples > 5 Units
Beaverton	1	2.9	1	2.6	2.6	100	1	5	1	5	5	0
Bertie Twp.	365	3.5*	365	3.5*	32.0	100	13	5	13	5	30	30
Brooklin	0	-	0	-	-	-	0	-	0	-	-	-
Dresden	12	18.0	365	2.0*	6.0	87	4	30	7	5	10	30
Dunnville	365	4.5*	365	4.5*	82.0	100	9	10	10	5	100	50
Eganville	1	2.5	1	2.5	-	-	1	35	1	35	35	100
Fauquier Twp.	0	-	0	-	-	-	0	-	0	-	-	-
Fenelon Falls	365	0.5*	365	0.5	0.5	0	4	20	5	10	20	60
Goderich	365	6.0*	365	0.9*	1.9	35	9	10	18	5	25	30
Harrow	6	24.0	6	7	20.0	100	2	30	1	20	20	100
King Twp. - Oak Ridges	1	6.0	1	4	4.0	100	1	5	1	5	5	0
- Schomberg	2	9.0	2	10.0	12	100	2	45	2	20	20	100
Lake Huron	365	3.0*	365	0.7*	10	32	1	5	1	5	5	0
Markham Twp.	0	-	0	-	-	-	0	-	0	-	-	-
Marmora	10	3.2	10	1.5	4.5	70	9	30	9	20	30	90
Meaford	365	1.3*	365	0.6*	7.8	14	1	5	1	5	5	0
Mitchell	2	5.2	2	2.3	3.3	100	2	10	2	5	5	0
Parkhill	0	-	0	-	-	-	0	-	0	-	-	-
Southampton	365	2.0*	365	0.2*	6.0	10	6	5	7	5	10	30
Union	365	12.0	365	0.2*	0.7	0	31	10	21	5	15	5
Warkworth	7	3.6	7	2.3	3.6	100	365	5*	7	10	20	60

* Modal value based on plant determinations

TABLE VII

CHEMICAL CHARACTERISTICS

1968

Project	Number of Samples		Hardness (mg/l $CaCO_3$)		Alkalinity (mg/l $CaCO_3$)		Iron mg/l Fe		Chloride mg/l Cl^-		pH		Fluoride mg/l F^-	
	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated
Beaverton	2	2	150	150	120	120	0.7	0.2	10	12	8.3	7.9	-	-
Bertie Twp.	12	12	140	140	100	100	0.4	0.3	28	29	8.0	8.0	0.1	0.2
Brooklin	3	3	260	260	230	230	1.0*	0.3*	6	9	7.4	7.6	-	-
Dresden	12	12	240*	100*	209	70	2.1	0.2	12	14	8.0	9.1	-	-
Dunnville	11	11	140	140	100	100	0.4	0.6	26	27	8.2	8.1	0.2	0.2
Eganville	1	1	50	50	40	40	0.7	0.3	3	5	8.0	7.8	-	-
Fauquier Twp.	0	0	-	-	-	-	-	-	-	-	-	-	-	-
Fenelon Falls	8	8	60	60	50	50	0.2	0.2	8	5	8.0	7.7	-	-
Goderich	22	22	130	130	100	100	0.9	0.1	13	14	8.1	8.0	0.1	-
Harrow	7	7	120	120	90	80	1.0	0.5	34	39	7.9	7.8	-	-
King Twp. - Oak Ridges	1	1	250	250	260	250	1.4	0.6	1	1	7.9	8.0	-	-
- Schomberg	12	12	230	180	310	330	1.3	0.8	2	7	7.8	7.8	-	-
Lake Huron	2	10	-	-	-	-	-	-	-	-	-	-	-	-
Markham Twp.	78	115	330	310	270	270	0.6	0.8	47	50	7.7	7.6	-	-
Marmora	10	10	90	90	80	70	0.2	0.2	3	5	8.0	7.8	-	-
Meaford	1	1	90	90	70	70	0.1	0.1	6	7	8.1	8.1	-	-
Mitchell	7	4	250	250	200	200	0.6*	0.6*	8	7	7.8	7.9	-	-
Parkhill	13	39	-	-	-	-	0.4	2.9	170	190	7.6	7.2	-	-
Southampton	8	8	110	110	90	90	1.0	0.2	7	18	-	8.2	-	-
Union	40	25	120	120	90	80	0.8	0.1	25	27	8.1	7.7	0.1	0.1
Warkworth	10	10	210	210	200	200	0.3	0.1	4	5	8.3	8.1	-	-

* Modal value based on plant determinations

OPERATING STAFF

Thirteen plants recorded labour charged to the project. Seven were operated by permanent employees, and six by part-time staff. Operating personnel for the remainder of the projects were provided by the municipalities. The staff employed at the water treatment plants is summarized in Table VIII with casual and part-time staff reported to the nearest one-tenth of a man-year.

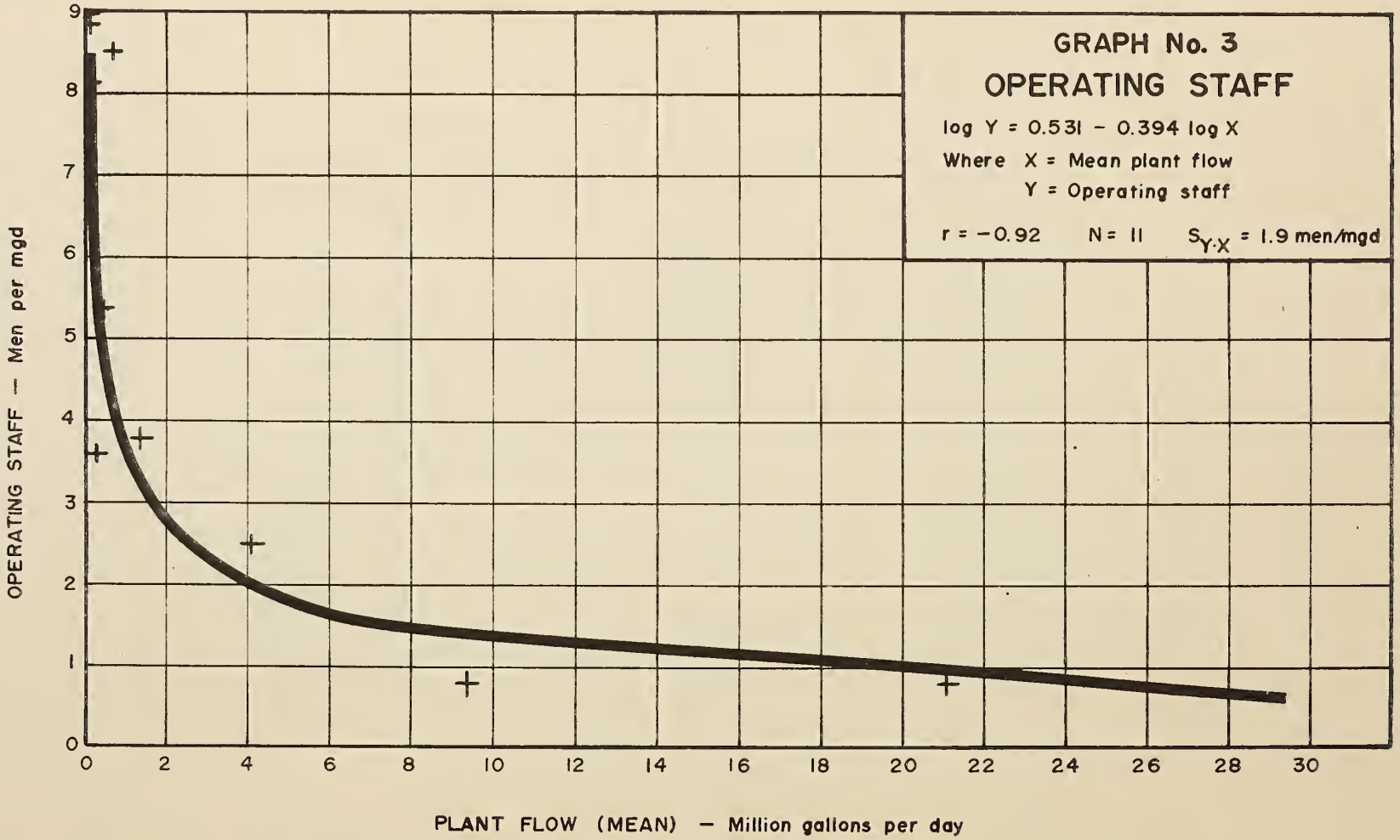
Of the seven plants employing full-time operators, Bertie Twp., Dunnville, Goderich, Lake Huron and Union were staffed 24 hours per day while Fenelon Falls and Markham Twp. were staffed 8 hours per day.

Graph No. 3 shows the relation of operating staff to plant flow excluding Oak Ridges, where no plant flows were available, and Markham Twp., where the plant staff is also responsible for operation and maintenance of a well and associated pumping station.

TABLE VIII OPERATING STAFF

PROJECT	SUPERINTENDENT	ASSISTANT SUPERINTENDENT	CHIEF OPERATOR	ASSISTANT CHIEF OPERATOR	MECHANIC	ELECTRICIAN	CONTROL TECHNICIAN	OPERATOR	LABOURER	GROUNDSMAN/ JANITOR	CASUAL/ PART TIME	TOTAL
Bertie Twp.	-	-	1	-	1	-	-	3	-	-	0.4	5.4
Brooklin	-	-	-	-	-	-	-	-	-	-	0.3	0.3
Dunnville	1	*	-	-	1	-	-	5	-	-	0.4	7.4
Fauquier Twp.	-	-	-	-	-	-	-	-	-	-	0.3	0.3
Fenelon Falls	-	-	1	-	-	-	-	-	-	-	0.2	1.2
Goderich	-	-	1	1	-	-	-	3	-	-	0.9	5.9
King Twp. - Oak Ridges	-	-	-	-	-	-	-	-	-	-	0.3	0.3
- Schomberg	-	-	-	-	-	-	-	-	-	-	0.3	0.3
Lake Huron	1	-	-	-	1	1	1	10	2	-	3.1	19.1
Markham Twp.	-	-	1	-	-	-	-	1	-	-	0.3	2.3
Southampton	-	-	-	-	-	-	-	-	-	-	1.0	1.0
Union	1	**	-	-	1	1	-	5	-	2	-	10.0
Warkworth	-		-	-	-	-	-	-	-	-	0.5	0.5

* Mechanic is Assistant Superintendent
** Electrician is Assistant Superintendent


GRAPH No. 3
OPERATING STAFF
log Y = 0.531 − 0.394 log X
Where X = Mean plant flow
Y = Operating staff
r = −0.92 N = 11 $S_{Y \cdot X}$ = 1.9 men/mgd
OPERATING STAFF — Men per mgd
PLANT FLOW (MEAN) — Million gallons per day
0
1
2
3
4
5
6
7
8
9
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

OPERATING COSTS

The cost of operation of the water treatment plants used in this report include payroll of staff employed at the plants, fuel, power, chemicals, general supplies, equipment, repairs and maintenance, sundry, water, and travel. The cost of head office supervision, including travel, accounting, purchase and inspection, is not charged against the project.

An explanation of items included in each of the categories of the operating costs follows:

1. Payroll
   - Regular: Staff salaries, including pension, medical plan, and Workmen's Compensation payments.
   - Casual: Salaries of labour employed on a temporary or part-time basis during staff shortages, or for part-time work. Workmen's Compensation payments are also included.
2. Fuel - Includes fuel oil, natural gas or propane used for heating.
3. Power - Includes hydro-electric power plus natural gas, gasoline, diesel fuel, if used for power generators.
4. Chemicals - Includes chlorine, sodium hypochlorite, diatomaceous earth, hydrated lime, alum, activated carbon and salt.
5. General Supplies - Includes laboratory reagents, laboratory equipment replacement, cleaning materials, lubricants, stationery, uniforms, light bulbs, instrument charts, books, etc.
6. Equipment - Includes equipment to be used in the treatment process, laboratory, building, grounds, maintenance, and small tools.
7. Repairs & Maintenance - Includes goods and services (excluding OWRC staff) used in the repair and maintenance of process, electrical equipment and buildings, inspections, packing materials, paints, etc.

8. Sundry - Includes express charges, telephone, telemetering, insurance, taxes, etc.

9. Water - Includes all charges for water.

10. Travel - Includes operators' travel to local hardware stores, railroad stations, conferences, conventions, etc. The cost of accommodation and meals associated with conferences and conventions is also included.

Table IX summarizes the total annual costs for the categories described above for each project.

The relation of unit operating costs in cents per thousand gallons to mean plant flows is shown in Graph No. 4. Only those plants for which complete operating costs were available were used, with the exception of the two King Twp. plants (zeolite softeners) and Markham Twp., where the separate well and pumping station costs were included in the total costs.

Unit costs for chemicals are shown as a function of nominal plant capacity in Graph No. 5. The costs used were for plants employing chemical coagulation. Factors such as raw water quality were not considered in this correlation.

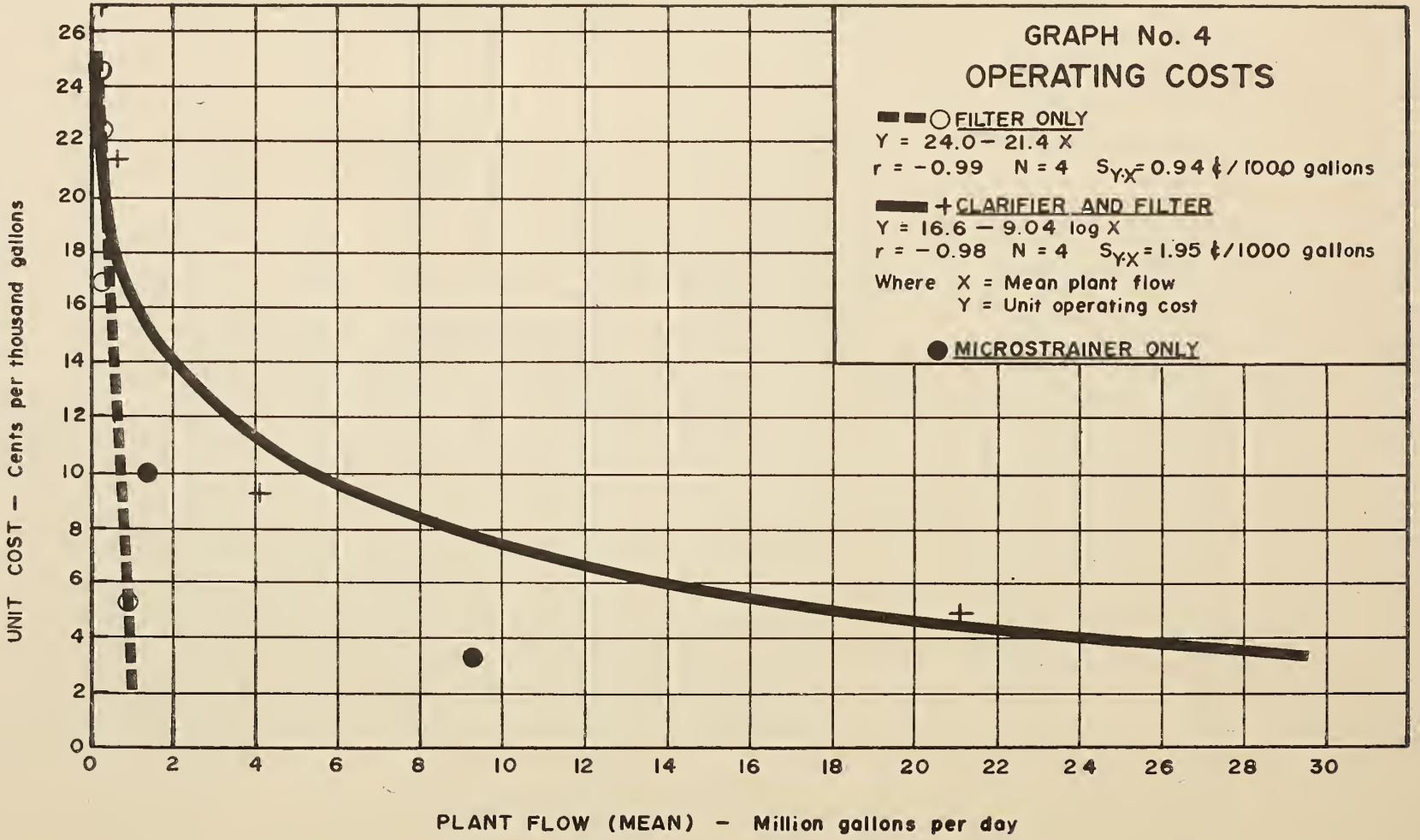
Graph No. 6 relates unit power costs to nominal capacity. Much of the variation can be attributed to the type of terrain, distances the water must be pumped, and whether the plant is electrically heated.

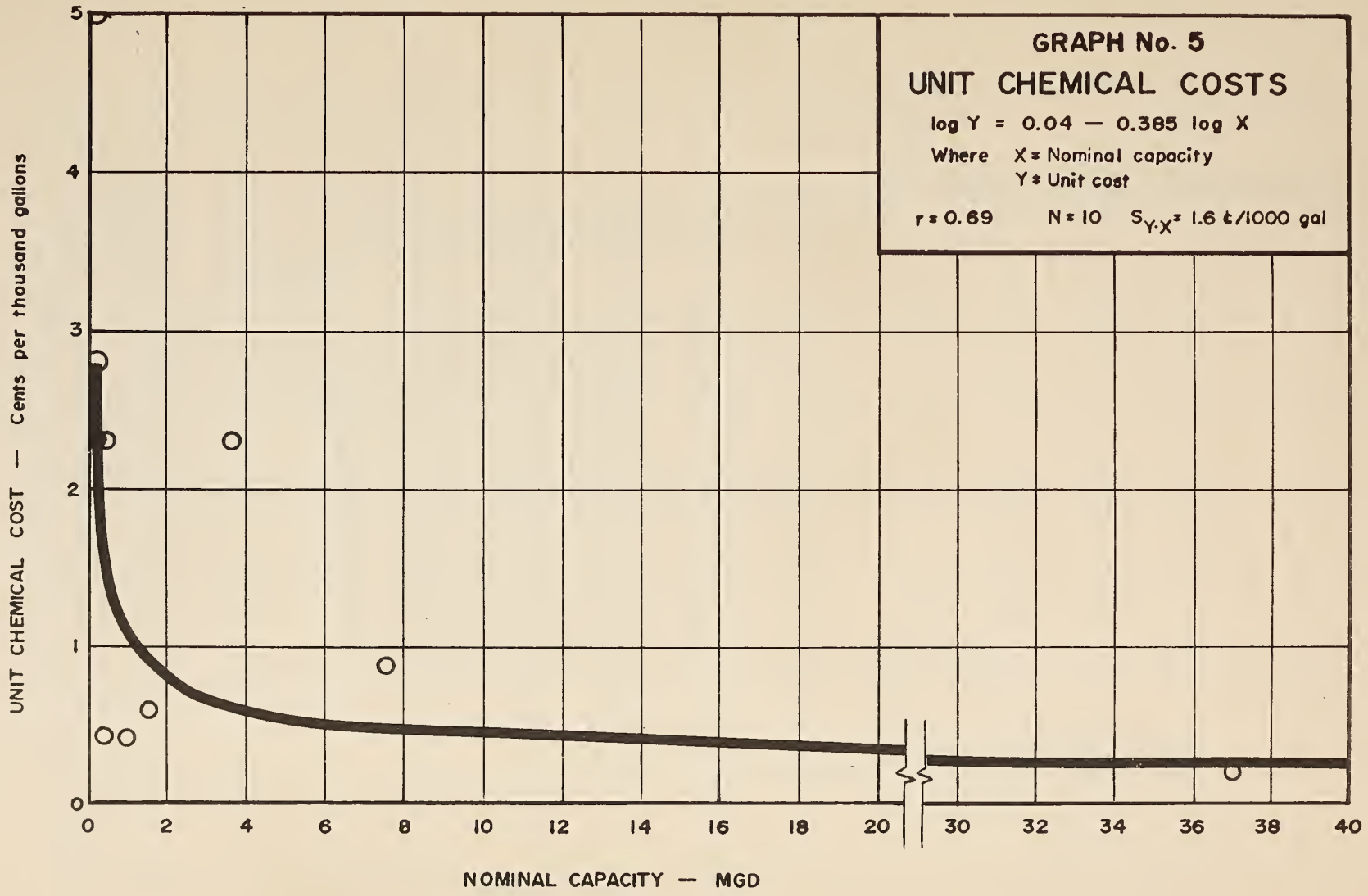
TABLE IX
Note: Units are Dollars

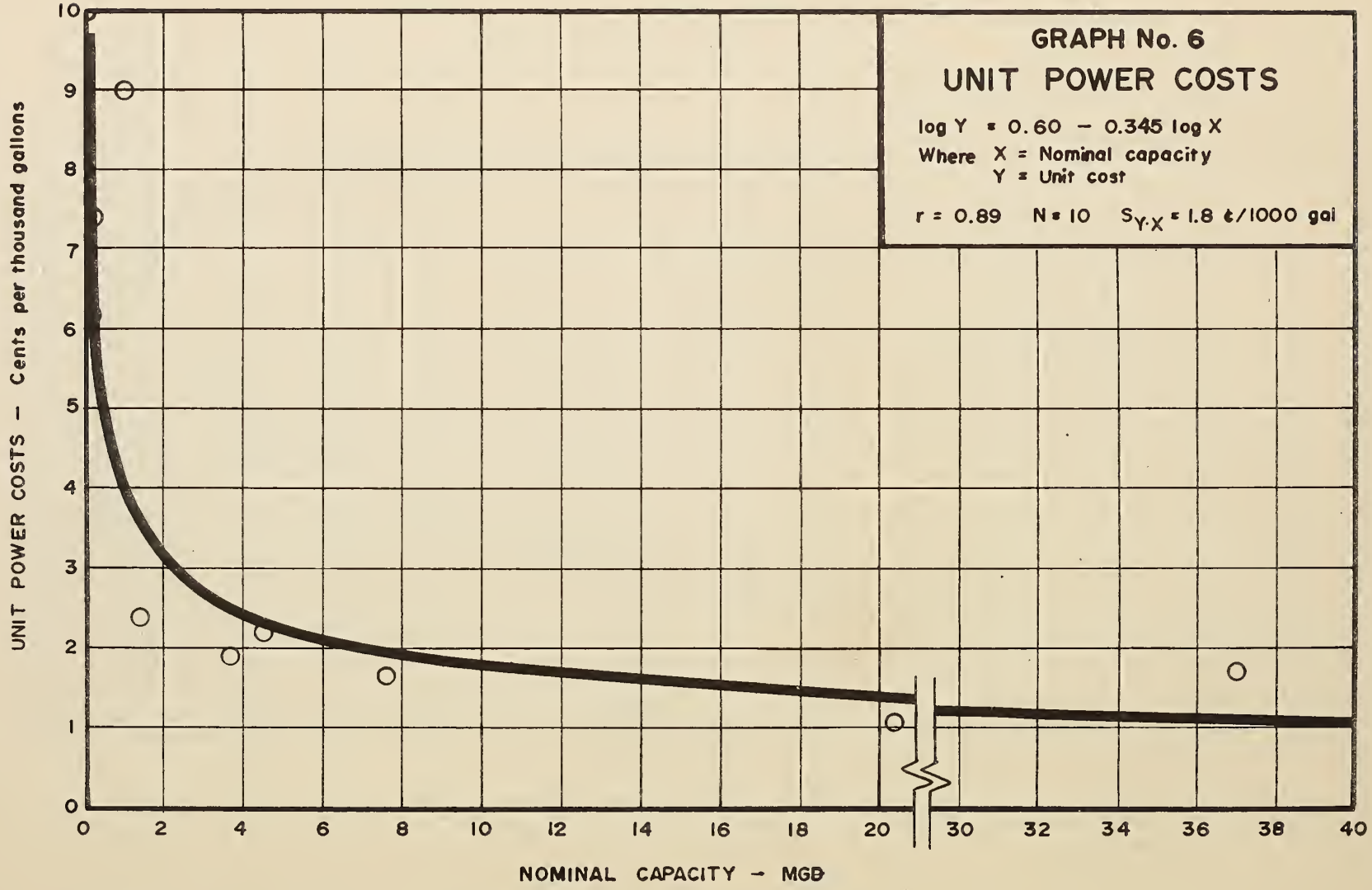
OPERATING COSTS

Project	Total Cost	Salaries Regular	Salaries Casual	Fuel	Power	Chemicals	General Supplies	Equipment	Repairs & Maintenance	Sundry	Water	Travel
Beaverton	213.42	-	-	-	-	-	1.37	-	94.00	118.05	-	-
Bertie Twp.	50998.06	29996.27	2267.82	939.80	11360.83	1141.97	996.64	285.93	2518.65	915.52	-	574.63
Brooklin	3351.90	-	1682.98	-	1007.48	320.00	27.67	-	243.48	70.29	-	-
Dresden	383.51	-	-	-	-	-	1.37	251.05	69.60	61.49	-	-
Dunnville	104861.63	46827.80	2659.43	655.23	36187.47	2773.50	2923.86	877.26	5776.96	5791.57	Cr. (68.97)	457.52
Eganville	743.52	-	-	-	-	524.45	37.69	-	99.53	81.85	-	-
Fauquier Twp.	2862.62	-	856.98	-	1578.04	100.00	131.79	-	107.76	88.05	-	-
Fenelon Falls	9072.02	6085.44	447.97	-	-	212.26	418.09	323.77	914.59	586.90	-	83.00
Goderich	53844.38	32127.71	2791.70	130.20	5742.31	1634.20	1200.76	132.77	930.06	8587.82	-	566.85
Harrow	534.14	-	-	-	-	-	66.21	251.05	-	211.84	-	5.04
King Twp. - Oak Ridges	3291.84	-	1375.77	-	1514.86	243.00	13.58	-	23.52	121.11	-	-
- Schomberg	4805.53	-	2143.34	-	1218.66	471.01	96.11	260.25	416.64	95.30	-	104.22
Lake Huron	351614.61	109150.96	14286.35	49.05	137241.94	16510.60	4503.48	6357.92	11944.19	47772.62	354.64	3442.86
Markham Twp.	34865.46	17868.69	-	253.97	11540.09	509.42	911.87	-	1016.82	1734.70	-	1029.90
Marmora	1864.04	-	-	-	-	1156.00	10.01	246.25	256.20	184.48	11.10	-
Meaford	16574.84	-	-	-	-	-	1.37	-	-	16573.47*	-	-
Mitchell	99.43	-	-	-	-	-	-	-	-	99.43	-	-
Parkhill	3011.94	-	-	-	-	781.60	190.11	-	658.43	1381.80	-	-
Southampton	16778.68	-	-	-	-	4054.67	139.44	456.40	3624.12	8504.05*	-	-
Union	137283.49	67822.71	91.28	2687.47	24889.47	13064.45	3758.37	573.19	4567.20	17970.27	-	1858.78
Warkworth	2986.69	-	1647.50	-	628.57	230.75	96.46	27.40	266.72	89.29	-	-

* Includes Labour and Power


GRAPH No. 4
OPERATING COSTS
FILTER ONLY
Y = 24.0 − 21.4 X
r = −0.99 N = 4 $S_{Y\cdot X}$ = 0.94 ¢/1000 gallons
CLARIFIER AND FILTER
Y = 16.6 − 9.04 log X
r = −0.98 N = 4 $S_{Y\cdot X}$ = 1.95 ¢/1000 gallons
Where X = Mean plant flow
Y = Unit operating cost
MICROSTRAINER ONLY
UNIT COST − Cents per thousand gallons
PLANT FLOW (MEAN) − Million gallons per day
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30


GRAPH No. 5
UNIT CHEMICAL COSTS
log Y = 0.04 — 0.385 log X
Where X = Nominal capacity
Y = Unit cost
r = 0.69 N = 10 $S_{Y \cdot X}$ = 1.6 ¢/1000 gal
UNIT CHEMICAL COST — Cents per thousand gallons
NOMINAL CAPACITY — MGD
0
1
2
3
4
5
0
2
4
6
8
10
12
14
16
18
20
30
32
34
36
38
40


GRAPH No. 6
UNIT POWER COSTS
log Y = 0.60 − 0.345 log X
Where X = Nominal capacity
Y = Unit cost
r = 0.89 N = 10 $S_{Y \cdot X}$ = 1.8 ¢/1000 gal
UNIT POWER COSTS – Cents per thousand gallons
NOMINAL CAPACITY – MGD
0
1
2
3
4
5
6
7
8
9
10
0
2
4
6
8
10
12
14
16
18
20
30
32
34
36
38
40


ONTARIO WATER RESOURCES COMMISSION